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Criteria for the Health Evaluation of Polymeric Materials Building

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Various polymer-based synthetic materials have become increasingly ubiquitous in manufactured materials in the U.S.S.R. These release various chemical compounds to the ambient air. The maximum permissible concentrations that have been established for various hazardous chemicals in ambient air must be adjusted to account for the conditions of apartment life. Studies have been conducted to determine exactly what compounds are released and at what rate. Toxicological studies and studies of various physical and chemical properties are required to determine the health effects of these chemicals at concentrations at which they are expected to occur in apartments. More research has to be carried out in this field to further expand our knowledge, and we must beware of any introduction of new polymeric materials without first studying their contribution to possible detrimental health effects.

The intensive development of the chemical industry in the Soviet Union has resulted in increased production of various polymer-based synthetic materials and their increasingly widespread use in the national economy.

In the last few years polymer materials have been widely used in the construction of apartment houses and public buildings, in the production of sanitary appliances for such buildings, for water installations, and in the manufacture of household products (food packaging, tableware, toys, etc.). Materials based on synthetic resins are also replacing traditional raw materials in the manufacture of furniture and in clothing and footwear, for which Kapron and the polyurethanes (Porolon) tend to be more and more used.

All this naturally poses some serious problems for the health sciences, as the original concept that polymers were biologically inert and could therefore be widely used for a number of products without hazard to public health was soon refuted by hygienists in light of research results.

The first studies in this field were carried out by the F. F. Erisman Hygiene Research Institute of Moscow, which as early as 1935 took interest in the properties of polymer products coming into contact with food. Since the early 1960s, a number of Soviet institutions (the A. N. Marazev Institute of General and Community Hygiene, Kiev; the Rostov Medical Institute, and the A. N. Sysin Institute of General and Community Hygiene, Moscow) have undertaken systematic studies on the health aspects of polymeric materials. It is characteristic that in the period 1961–1963, only occasional and uncoordinated research was carried out into the thermophysical properties of synthetic floor coverings and their effects on the heat-exchange function in man. Later, such studies included the accumulation of static electricity on the surface of polymer materials. It should be pointed out that the methods for the investigation of chemicals that may be released by polymers were greatly helped by studies that were originally carried out to determine appropriate models for sanitary-chemical and sanitary-toxicological research.

In response to growing practical needs for evaluating the safety of polymers and products containing them, at the end of 1964, the U.S.S.R. Ministry of Health established the All-Union Research Institute on the Hygiene

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and Toxicology of Pesticides, Polymers, and Plastics (VNIIGINTOKS). This became the main research center for work on a subject of national importance, i.e. the provision of scientific guidance to the toxicology and hygiene of pesticides, polymers and plastics.

At the same time, investigations were being carried out on polymeric products used in water supply systems (at the First Moscow Medical Institute and at the A. N. Marazev Institute of General and Community Hygiene, Kiev) and in synthetic clothing and footwear (A. N. Sysin Institute of General and Community Hygiene, Moscow, and the F. F. Erisman Institute, Moscow). More detailed studies on the manufacture of polymers and their safe application in various branches of the national economy provided a basis for more extensive and more precisely oriented health research in this field. They also led, on the part of the institutions of the Sanitary-Epidemiological Service, to more extensive surveillance of the manufacture of polymers and items containing polymers and their use in the building industry.

With the gradual establishment of sanitary surveillance, there emerged a need to define some quantitative parameters characterizing those properties of polymers important from the health point of view. Of primary importance are those properties and processes by which monomers and other constituents of polymeric materials or their thermal and photochemical degradation products may be released into the environment. These substances and compounds may, in turn, enter the organism by inhalation, skin contact, or ingestion. There is now no doubt about the need to establish health standards for such hazardous chemicals.

Health standardization of polymers used in water supply practice already has a definite tradition, but only the first attempts are being made to elaborate maximum permissible concentrations (MPC) for hazardous substances released from polymerous materials in contact with food, while the setting of standards for air-borne substances in apartments and other premises with equivalent health requirements is even less advanced.

Some time ago we set forth the principles for health standards of polymeric building materials. The basic principle is that the air of apartments and other premises with strict health requirements must not contain chemicals in concentrations that would adversely affect the human organism. These requirements cover not only changes leading to overt pathological conditions but also possible long-term or delayed effects that may become apparent in future generations, such as mutagenic or teratogenic effects.

The principles and methods used for determining the MPC in the ambient air, however, cannot be applied to the chemicals released from polymers in building materials. For not only must the properties and composition of the indoor air be considered, but also the fact that it is practically impossible to establish an MPC for the multicomponent mixtures of chemicals found in the air of rooms where polymers may have been used only for "finishing" materials but also as an integral part of the fabric of furniture, clothing or footwear.

The mixtures of chemicals released into the air of modern apartments containing polymerous materials may be so different and may contain so many components that it does not seem possible to predict their composition. Those materials, moreover, may release not only chemically inert substances but also compounds that are reactive enough to produce new chemical compounds in the air. The probability of forecasting not only the concentration but also the chemical composition of these compounds is very small.

The joint effects of mixtures of chemical substances that can change both qualitatively and quantitatively can be determined only by toxicological experiments under closely simulated real-life conditions. Even the results of this type of experiment can only be applied with a limited degree of probability. For this reason we should be even more cautious in the use of isolated toxicological studies.

Toxicological studies have an undoubted value, nevertheless, at a certain stage of investigation of these materials, and we must have some criteria for their evaluation.

For practical purposes, the MPC values established for hazardous chemicals in the ambient air may be used as such criteria, although they are very approximate and have to be adapted to indoor air conditions. If studies on the composition of the indoor air show that hazardous substances are being released from polymeric materials in concentrations of the order of the MPC for the ambient air (which

have been established by use of safety factor) or at levels below them, further studies using animal experiments should be carried out to determine possible biological effects. If, however, the concentrations of the hazardous chemicals exceed the MPC, there is no need for further studies and the use of the materials giving off the hazardous chemicals should be prohibited in the construction of residential buildings.

In the Soviet Union there is a list of those basic chemical substances most often released from polymerous building materials and for which maximum permissible concentrations have been proposed by the All-Union Research Institute for Pesticides, Polymers and Plastics, in agreement with other hygiene research institutes. These MPC levels are based on concentration, cumulative properties, toxicity parameters, duration of human exposure, and the possible chronic or delayed effects of such exposure, and on the microclimatic conditions in the apartments. Having determined the concentration of the principal hazardous substances likely to be released by a material of given composition, one can make a preliminary evaluation of that material and determine its field of application from the viewpoint of hygiene. Should several toxic substances be released simultaneously by the material in question, a well-known formula may be used for establishing an MPC for mixtures.

Such documentation on MPC of harmful chemical substances released from such building materials which regulates, at a given state of knowledge, the surveillance of the manufacture and application of polymers in building materials is, however, only an interim measure that presupposes further and more detailed study aimed at the establishment of health standards for such substances.

It should be pointed out that any health assessment of new polymeric materials should include toxicological investigations to ascertain the type of biological effects associated with mixtures of volatile chemical substances released. The toxicological experiments should be carried out on the most sensitive laboratory animals with respect to both species and age. In addition to these toxicological criteria for the health assessment of the materials in question, other characteristics of the materials should also be investigated. For example, the no-effect level for static electricity potential has been set at 200 V, a value that will exclude any electrical discharge when an earthed object is touched. It should be borne in mind, however, that the potential on the surface of the human body may often be considerably higher than the potential on the floor surface, as static electricity may accumulate on the body surface. The health standard in this instance, of course, refers to the environment, i.e., it determines the permissible potential of the polymer surface, not of the human body.

Standards for the heat-insulating properties of polymer building materials are generally accepted and have been included in the building standards and regulations.

It should also be remembered that the effects on the human organism of static electricity, odors, or thermal discomfort from these materials may be small in themselves, yet their continuing influence on the human organism may induce a series of nonspecific deviations from the normal physiological state of the organism and a possibly greater susceptibility to the effects of other factors, including infectious agents.

This paper covers only the main health requirements in regard to polymeric building materials, which are based on a relatively small number of studies. As more information becomes available in the future, stricter and more comprehensive requirements may be anticipated. Certain progress has been made in the Soviet Union towards improving the properties of polymers, and Soviet hygienists have accomplished a useful function in concentrating attention on the potential hazards to human health from the uncontrolled use of polymeric building materials in apartments. Soviet sanitary law no longer permits use of new polymeric building materials without a prior evaluation of their contribution to possible detrimental health effects.